UNCLASSIFIED

AD 667 644

ELECTRICAL CONDUCTIVITY OF CADMIUM OXIDE IN HIGH-FREQUENCY ELECTRICAL FIELDS

R. A. Baltrushaitis, et al

Foreign Technology Division
Wright-Patterson Air Force Base, Ohio

10 August 1967

FTD-HT-23-657-67

FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

ELECTRICAL CONDUCTIVITY OF CADMIUM OXIDE IN HIGH-FREQUENCY ELECTRICAL FIELDS

by

R. A. Baltrushaytis and P. P. Brazdzhyunas

50 YEARS
1917 1967
GOLDEN ANNIVERSARY
FOREIGN TECHNOLOGY DIVISION

This translation was made to provide the users with the basic essentials of the original document in the shortest possible time. It has not been edited to refine or improve the grammatical accuracy, syntax or technical terminology.

FTD-HT-23-657-67

UNEDITED ROUGH DRAFT TRANSLATION

ELECTRICAL CONDUCTIVITY OF CADMIUM OXIDE IN HIGH-FREQUENCY ELECTRICAL FIELDS

By: R. A. Baltrushaytis and P. P. Brazdzhyunas

English pages: 7

SOURCE: Litovskiy Fizicheskiy Sbornik (Lithuanian Physical Collection), No. 4, 1964, pp. 537-541.

Translated by: F. Dion/TDBXT

TT7001013

PREPARED BY:

TRANSLATION DIVISION
FOREIGN TECHNOLOGY DIVISION
WP-AFB, OHIO.

ITIS INDEX CONTROL FORM

01 Acc Nr	68 Translation Nr	65 X Ref Acc Nr	76 Reel/Frame Nr
TT7001013	FTD-HT-23-657-67	BJ6003960	1881 1235

97 Header Clas	63 Clas	64 Control Markings	94 Expansion	40 Ctry Info
UNCL	UNCL, 0	0		UR

02 Ctry	03 Ref	04 Yr	05 Vol	06 Iss	07 B. Pg.	45 E. Pg.	10 Date
UR	0000	64	000	004	0537	0541	NONE

Transliterated Title

ELEKTROPROVODNOST' OKISI KADMIYA V VYSOKOCHASTOTNYKH ELEKTRICHESKIKH POLYAKH

09 English Title ELECTRICAL CONDUCTIVITY OF CADMIUM OXIDE IN HIGH-FREQUENCY ELECTRICAL FIELDS

43 Source

LITOVSKIY FIZICHESKIY SBORNIK (RUSSIAN)

42 Author	98 Document Location
BALTRUSHAYTIS, R. A.	
16 Co-Author	**47 Subject Codes**
BRAZDZHYUNAS, P. P.	20
16 Co-Author	**39 Topic Tags:**
NONE	electric conductivity, cadmium oxide, high frequency, electric field
16 Co-Author	
NONE	
16 Co-Author	
NONE	

ABSTRACT : Results are given of an investigation into the electrical conductivity of polycrystalline samples of cadmium oxide using the non-electrode method in the frequency range $(7-8.9)\cdot 10^9$ cps. English Translation: 7 pages.

FTD Form Feb 67 0-90

U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

* <u>ye</u> initially, after vowels, and after ъ, ь; <u>e</u> elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

ELECTRICAL CONDUCTIVITY OF CADMIUM OXIDE IN HIGH-FREQUENCY ELECTRICAL FIELDS

R. A. Baltrushaytis and
P. P. Brazdzhyunas

(Submitted 25 December 1963)

Certain results of an investigation of the electrical conductivity of polycrystalline CdO samples using the nonelectrode method in the frequency range of $(7-8.9)\cdot10^9$ Hz are introduced.

1. Introduction

During heat treatment of polycrystalline SdS and CdSe samples in an oxygen atmosphere their electrical conductivity and photosensitivity increase [1, 2, 3]. The increase in electrical conductivity can be caused by the cadmium oxide that forms in polycrystalline layers during their heat treatment [1]. It is assumed that the polycrystalline semiconductor sample consists of the large number of chaotically oriented crystallites of the semiconductor substance separated by interlayers.

In polycrystalline CdS and CdSe samples the interlayers form impurities (in particular, CdO [1]) that have comparatively low resistance. At high frequencies the total resistance of a sample is composed of the resistance of the interlayers, since the crystallites are shunted by the surface capacitance.

In this work we investigated the electrical conductivity of CdO at superhigh frequencies and we compared the obtained results with the results of measurments conducted on dc.

2. Experimental Method

The coefficient of power absorption for a plane electromagnetic wave [4,5] in a medium with a refracted index n is

$$k=\sigma/nc\varepsilon_0, \tag{1}$$

where σ is the electrical conductivity of the medium, ε_0 is the dielectric constant of a vacuum and c is the velocity of light. In works [6, 7, 8] the coefficient of absorption was determined from the ratio between the incident and the transmitted powers. If the sample thickness and the frequency of the electromagnetic field remain constant, we can also determine the electrical conductivity of samples from this power ratio.

As is known, the electrical conductivity σ at high frequencies is connected with the dc electrical conductivity σ_0 by the following relationship:

$$\sigma=\sigma_0\left\langle\frac{\tau}{1+\omega^2\tau^2}\right\rangle\Big/\langle\tau\rangle, \tag{2}$$

where τ is the time of the mean free path, ω is the angular frequency of excitation. The dc electrical conductivity is

$$\sigma_0=e(u_nN_n+u_pN_p), \tag{3}$$

where e is the charge on the electrode, u is the mobility and N is the concentration of current carriers. If $\omega^2\tau^2 \ll 1$, then $\sigma \approx \sigma_0$. Then, σ can replace σ_0 in relationship (1).

Assuming that n does not depend upon frequency, i.e., that the free current carriers do not give a significant contribution to the dielectric constant of the sample, and that the magnetic permeability $\mu = 1$, the absorption coefficient k can be expressed in the following manner [6]:

$$k = 1635\,\sigma/n. \quad (4)$$

In this case k will be measured in dV/m. Knowing the absorption coefficient and the refracted index, we can compare a sample's electrical conductivity measured at high frequencies with its dc electrical conductivity.

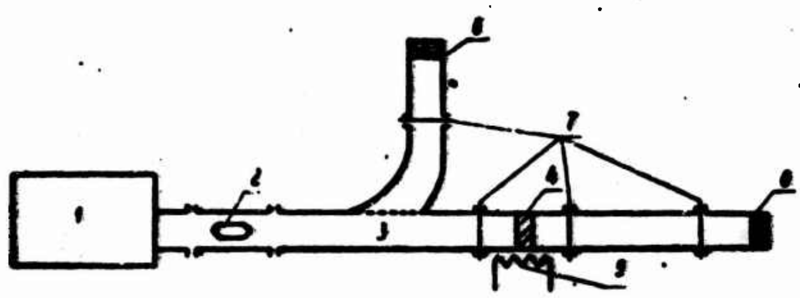

Fig. 1. Block diagram of the set-up; 1) SHF generator; 2) attenuator; 3) directional coupler; 4) sample; 5) heating element; 6) bolometric heads; 7) mica inserts.

The incident and transmitted powers were measured with the device shown on Fig. 1. SHF powers ($(7\text{-}8.9)\cdot10^9$ Hz) from generator (1) were fed into a waveguide made completely of semiconductor substance (4). The waveguide track was decoupled by an attenuator placed directly in the instrument, and the signal level was regulated by an additional attenuator (2). In determining the incident power we calculated the reflected power, since

$$P_i = P_0 - P_r,$$

where P_0 is the power comming from the generator, and P_r is a power reflected from the sample. For this purpose we used a directional coupler (3) that was graduated in frequencies. The SHF power in the waveguide track was measured by bolometric heads (6).

We established that the power ratio of the transmitted to incident power P_{tr}/P_i does not depend upon the location of the sample in the waveguide. To measure the dependence of the P_{tr}/P_i ratio upon temperature, heating elements (5) allowing us to heat the sample up to 100°C were placed on the waveguide. To eliminate the effect of the heaters on the indicators, water coolers were placed before the bolometric heads and the waveguide sections were separated by mica plates (7). But at a temperature of 80-90°C the operating conditions of the bolometric heads were disturbed, which hampered measurements at higher temperatures. The dc electrical conductivity was measured by the usual method with a M-21/1 galvanometer.

CdO samples were prepared in special press-forms under a pressure of 0.9-3.6 kg/m^2 and were later subjected to four hours of heat treatment at 100-550°C. The samples were then carefully ground down to dimensions equal to the transverse cross section of the waveguide. The prepared samples had a thickness from 0.001 to 0.003 m. Thinner samples were pressed and hardened for four hours at 100°C directly in the waveguide. Some samples were not subjected to heat treatment.

To measure the temperature dependence of the dc electrical conductivity, silver or aquadag [a graphite lubricant] contacts were placed on the samples.

3. Discussion of the Results

From the measured ratio of the transmitted and incident powers we calculated the coefficient of absorption and the electrical conductivity of a sample. The values of the electrical conductivity measured at high frequencies (Fig. 2) are in good agreement with the results of the dc measurements. We noted that the samples hardened at higher temperatures had increased conductivity. The pressure used to press the samples did not have a significant effect.

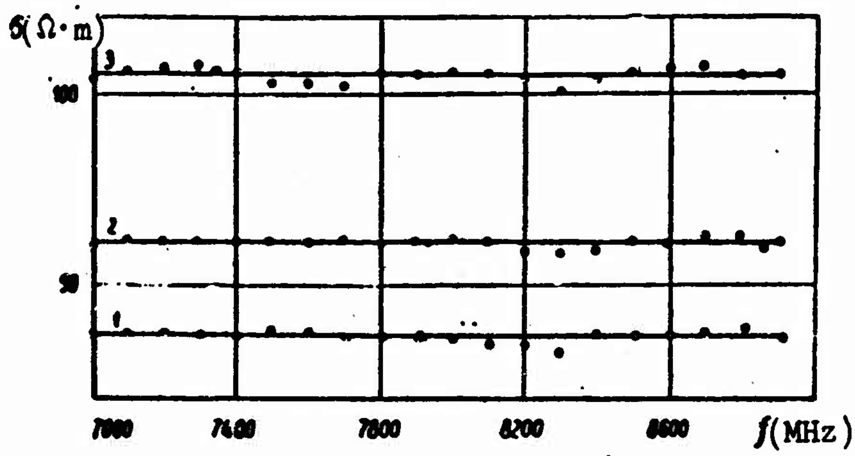

Fig. 2. Dependence of the reduced electrical conductivity upon the frequency of samples heated at 100C (1), 250C (2), 450C (3).

To reveal the temperature dependence of the electrical conductivity of CdO samples, we measured it on dc in the temperature interval of 200-400C. The results of this measurement are given on Fig. 3. From this dependence we calculated the energy of thermal activation ΔE for both dc and SHF. At 20-80C, ΔE was 0.032 and 0.027-0.029 eV respectively.

The values of the dependence of the absorption coefficient upon the conductivity determined by the test agree very well with theoretical calculations according to relationship (1) (Fig. 4).

From the above we can assume that in the given frequency range the refractive index n does not depend upon frequency, and the electrical conductivity did not change for dc or ac, i.e., $\sigma \approx \sigma_0$.

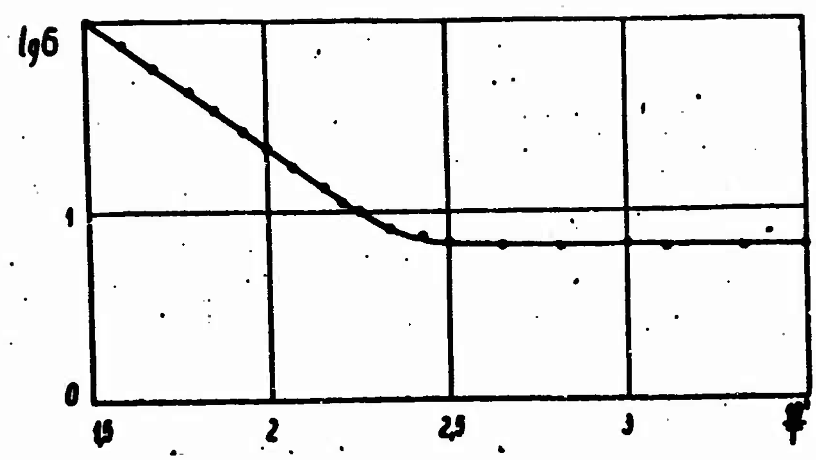

Fig. 3. Dependence of the dc electrical conductivity upon temperature in the interval of 20-400C.

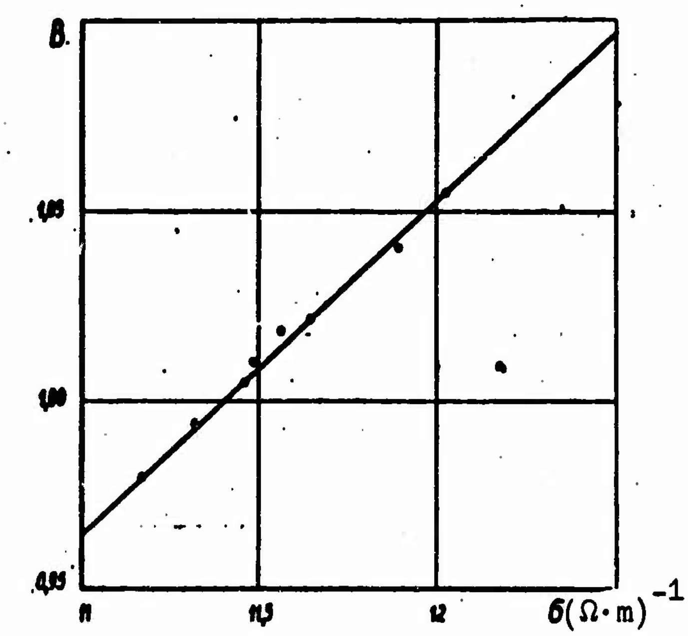

Fig. 4. Dependence of the absorption coefficient (in arbitrary units) upon the electrical conductivity of the samples: the solid line, theoretical; the points, experimental results.

Therefore, we can consider that $\omega^2\tau^2 \ll 1$. The values of the thermal activation energy measured by the SHF method in the temperature interval of 20-80C are in good agreement with the values of the thermal activation energy for the impurity levels measured on dc.

The authors express their gratitude to S. Kal'venas and I. Gashka for valuable advice.

Vilnius State University
named after V. Kapsukas

Literature

1. B. G. Kolomiyets. DAN SSSR, 83, 561 (1952).

2. A. Shirvaytis. Uchennyye zapiski VGU (Scientific Notes of Vilnius State University), XXXIII, 187 (1960).

3. Yu. K. Bishchakas, R. A. Baltrushaytis, P. P. Brazdzhyunas. Uchennyye zapiski VGU (Scientific Notes of Vilnius State University), XXXIII, 171 (1960).

4. R. Smit. Poluprovodniki (Semiconductors), Il, Moskva, 1962.

5. S. P. Kal'venas and Yu. K. Pozhela. Liet. fiz. rinkinys, 2, 3-4, 297 (1962).

6. A. F. Gibson, Proc. Phys. Soc., B 69, 4, 488 (1956).

7. H. Jacobs, F. A. Brand, J. D. Meindl, S. Weite, R. Benjamin. IRE Inter. Con. Res., 3, March 26-29, 30 (1962).

8. H. Jacobs, F. A. Brand, J. D. Meindl, M. Benanti, M. Benjamin. TUPU, 49, 5, 1086 (1961).

Summary

Some results obtained from the without electrodes measurements of conductivity of polycrystal specimens from CdO are given. The measurements have been made over the frequency range $(7\text{-}8.9)\cdot 10^9$ cycles.

V. Kapsukas State University Vilnius